US006587320B1

(12) **United States Patent**
Russ et al.

(10) **Patent No.: US 6,587,320 B1**
(45) **Date of Patent: Jul. 1, 2003**

(54) **APPARATUS FOR CURRENT BALLASTING ESD SENSITIVE DEVICES**

(75) Inventors: **Christian Cornelius Russ**, Princeton, NJ (US); **Koen Gerard Maria Verhaege**, Princeton, NJ (US)

(73) Assignee: **Sarnoff Corporation**, Princeton, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 213 days.

(21) Appl. No.: **09/583,141**

(22) Filed: **May 30, 2000**

Related U.S. Application Data

(60) Provisional application No. 60/174,326, filed on Jan. 4, 2000.

(51) **Int. Cl.**[7] **H02H 9/00**
(52) **U.S. Cl.** **361/56**; 257/361
(58) **Field of Search** 361/56, 91.1, 91.5; 257/361, 357, 355, 360

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,306,246	A		12/1981	Davies et al.
4,811,155	A		3/1989	Kuriyama et al.
4,930,036	A		5/1990	Sitch
5,218,222	A		6/1993	Roberts
5,248,892	A	*	9/1993	Van Roozendaal et al. . 257/357
5,404,041	A	*	4/1995	Diaz et al. 257/360
5,477,414	A	*	12/1995	Li et al. 361/56
5,498,892	A		3/1996	Walker et al.
5,547,881	A		8/1996	Wang et al.
5,602,409	A		2/1997	Olney
5,620,920	A		4/1997	Wilmsmeyer
5,637,902	A		6/1997	Jiang
5,640,299	A	*	6/1997	Leach 361/56
5,654,860	A		8/1997	Casper et al.
5,663,589	A	*	9/1997	Saitoh et al. 257/401
5,721,439	A		2/1998	Lin

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

DE	196 51 247	10/1997
EP	0 011 879	6/1980
EP	0355501 A2	8/1989
EP	0 387 944	9/1990
EP	0441126 A2	1/1991
EP	0656659 A2	12/1994
EP	0730332 A1	9/1996
GB	1 380 427	1/1975
JP	8-8441	1/1996

OTHER PUBLICATIONS

PCT International Search Report, Apr. 12, 2001.

Primary Examiner—Brian Sircus
Assistant Examiner—Zeev Kitov
(74) *Attorney, Agent, or Firm*—William J. Burke

(57) **ABSTRACT**

A current ballasting circuit for an ESD protection device couples nonintersecting conductive strips between a common contact pad and the contact electrodes of the ESD protection device. The connecting strips form respective electrically isolated ballasting resistors between the external contact pad and the contact electrodes of the ESD device. In addition, lateral resistances are formed between the contact strips which enhance the operation of the multiple ballasting resistors. The conductive strips may be made from metal, polysilicon or by a vertically meandering series connection of polysilicon layers, metal layers and interconnecting vias. The lateral resistance between the parallel conductive paths may be enhanced by segmenting both the drain and source electrodes. In one example, the gate electrode of an MOS ESD device extends locally between each pair of strips to segment the drain and source regions. The lateral resistance between the conductive strips is further enhanced by defining an additional gate electrode, having a portion that is parallel to the gate electrode of the ESD device and further portions that extend between the conductive strips. Multiple ESD devices may be connected in parallel to provide additional paths for shunting ESD current.

18 Claims, 6 Drawing Sheets